DESCRIPTION AND OCCURRENCE OF POSTLARVAL STAGES OF RATTAIL FISHES (MACROURIDAE) IN THE WESTERN ROSS SEA, ANTARCTICA

by

M. LA MESA (1), A. GRANATA (2), L. GUGLIELMO (2) & M. VACCHI (3)

ABSTRACT. - Postlarval stages of rattail fishes (family Macrouridae) were collected in the western Ross Sea in November 1989-January 1990 and November 1994-January 1995. All 23 specimens caught were identified as *Macrourus whitsoni* (Regan, 1913), one of the few macrourid species inhabiting the Southern Ocean south of the Polar Front. Body morphology and pigmentation patterns of some developmental stages of this species are described. Most captures were in the upper layer of the water column within 300 m depth and close to the seasonal thermocline. The stomach content of one individual constituted exclusively of several copepods.

RÉSUMÉ. - Description et répartition de stades postlarvaires de grenadiers (Macrouridae) en mer de Ross occidentale, Antarctique.

Des postlarves de grenadiers (famille Macrouridae) ont été récoltées entre novembre 1989-janvier 1990 et novembre 1994 -janvier 1995 en Mer de Ross occidentale. Les 23 exemplaires collectés ont été identifiés comme *Macrourus whitsoni* (Regan, 1913), une espèce répandue dans l'Océan Austral au sud du Front Polaire. Les caractères morphologiques et la pigmentation de quelques stades larvaires de cette espèce sont décrits. La plupart des captures proviennent de la couche supérieure de la colonne d'eau au-dessus de 300 m de profondeur et près de la thermocline. Le contenu stomacal d'un exemplaire était constitué exclusivement de nombreux copépodes.

Key-words. - Macrouridae, *Macrourus whitsoni*, PSE, PSW, Antarctica, Ross Sea, Larvae, Morphology, Distribution.

Rattail fishes or grenadiers constitute a large and diverse family (Macrouridae) of about 300 species of primarily benthopelagic deep-sea fishes inhabiting all oceans (Cohen *et al.*, 1990). More than 90 per cent of these live close to the continental slopes from 200 to 2000 m depth, where many species are quite abundant (Marshall, 1965). In the Southern Ocean, however, grenadiers are represented by only nine species (Table I), four of which apparently are endemic to this area (Iwamoto, 1990).

Despite the small number of macrourids in Antarctic waters, a few descriptions of the early life history stages of these species and no references to their identification are available. Efremenko (1985) described larvae of a macrourid, which he identified as *Macrourus whitsoni*, caught off South Georgia in the Scotia Sea. More recently, Kellermann

---

(1) Istituto di Ricerche sulla Pesca Marittima (IRPEM) del Consiglio Nazionale delle Ricerche (CNR), Largo Fiera della Pesca 1, 60125 Ancona, ITALY. [lamesa@irpem.an.cnr.it]

(2) Dipartimento di Biologia Animale ed Ecologia Marina, Università di Messina, Salita Sperone 31, 98166 Messina, ITALY.

(3) Istituto Centrale per la Ricerca Scientifica e Tecnologica Applicata al Mare (ICRAM), Via di Casalotti 300, 00166 Roma, ITALY.

Cybium 1999, 23(4): 391-399.

(1989) reported the specimens of Efremenko (1985) as *M. holotrachys*, perhaps as a synonym of the former species. Descriptions of egg and embryo morphology of *M. whitsoni* have been provided by Ciechomski and Booman (1981) from fishes caught on the Patagonian shelf off Argentina. Finally, Evseenko and Efremenko (1988) described a 14.3 mm SL larva of *Cynomacrurus piriei* collected in the upper 100 m in the Ross Sea.

The few data on early life history stages of macrourids, as reported from other areas such as the North Atlantic (Merrett, 1978) and the North Pacific (Stein, 1980), could

Table I. - Occurrence of macrourids in the Ross Sea from Iwamoto, 1990. Numbers in brackets refer to CCAMLR areas.

Species	**Polar distribution**	**Habitat**
Coelorinchus fasciatus Günther, 1878	South Georgia (48)	benthopelagic
Coelorinchus marinii Hubbs, 1934	South Georgia (48)	benthopelagic
Coryphaenoides armatus Hector, 1875	marginal, off APF (48-58)	benthopelagic
Coryphaenoides ferrieri Regan, 1913	endemic (48-58-88)	benthopelagic
Coryphaenoides filicauda Günther, 1878	marginal, off CCAMLR areas	benthopelagic
Coryphaenoides lecointei Dollo, 1900	endemic (48-88)	benthopelagic
Cynomacrurus piriei Dollo, 1909	endemic (48-58-88)	bathypelagic
Macrourus carinatus Günther, 1878	Crozet, Prince Edward (58)	benthopelagic
Macrourus holotrachys Günther, 1878	Shag Rock (SG)(48)	benthopelagic
Macrourus whitsoni Regan, 1913	endemic (48-58-88)	benthopelagic

Table II. - Sampling data recorded during the Italian Antarctic Oceanographic Cruises carried out in the western Ross Sea during November 1989-January 1990 and November 1994-January 1995.

Station	**Date**	**Longitude**	**Latitude**	**Sampling depth (m)**	**Bottom depth (m)**	**Specimens**	**Total length (mm)**
7/2	17-12-89	176°24'40 E	69°34'90 S	160-200	3505	1	11.7
7/5	17-12-89	176°24'40 E	69°34'90 S	100-120	3505	1	12
8/1	22-12-89	178°06'30 E	70°41'60 S	0-200	3350	1	11.6
8/6	22-12-89	178°06'30 E	70°41'60 S	80-100	3350	1	13
9/1	21-12-89	176°27'10 E	70°12'30 S	0-1000	3285	1	10.6
9/7	21-12-89	176°27'10 E	70°12'30 S	300-400	3285	1	11.7
9/8	21-12-89	176°27'10 E	70°12'30 S	200-300	3285	1	12.1
9bis/4	22-12-89	176°27'60 E	70°11'20 S	120-140	3290	1	13.2
10/1	23-12-89	179°40'50 W	71°12'70 S	0-200	1325	3	11.8-12.2-11.6
10/6	23-12-89	179°40'50 W	71°12'70 S	80-100	1325	1	11.2
10/8	23-12-89	179°40'50 W	71°12'70 S	40-60	1325	1	13
10bis/4	23-12-89	179°49'30 W	71°10'00 S	600-700	1340	1	12.7
10bis/8	23-12-89	179°49'30 W	71°10'00 S	200-300	1340	1	13.1
10bis/10	23-12-89	179°49'30 W	71°10'00 S	0-100	1340	3	13-12.8-12.6
15/1	28-12-89	179°54'40 E	72°19'60 S	0-200	2120	1	12.1
15/2	28-12-89	179°54'40 E	72°19'60 S	160-200	2120	1	12.4
V16	25-12-94	174°28'51 E	70°41'27 S	20-100	2410	1	18
V17	25-12-94	173°36'18 E	70°43'09 S	30-90	1983	1	20.3
24A	9-12-94	174°55'98 E	72°22'85 S	0-450	470	1	14.9

be partially explained by Marshall's (1965) hypothesis of the reproduction and development of these fishes. This latter author suggested that macrourid eggs are released and fertilised near the bottom, developing as they float slowly upward, and that the larvae probably live not far below the seasonal thermocline, descending towards deeper waters and reaching the deep-sea floor as they develop into the juvenile stage.

This paper reports on the macrourid larvae and postlarvae collected in the western Ross Sea and provides a detailed description of an almost complete developmental series of *M. whitsoni*. The present description, based on the largest sample reported from this area, was compared with the available literature.

MATERIALS AND METHODS

The macrourid larvae and postlarvae were collected during two Italian Antarctic oceanographic cruises carried out in the western Ross Sea between November 1989 and January 1990, and between November 1994 and January 1995. The sampling programme and total catches of both cruises are reported in Guglielmo *et al.* (1992), Granata *et al.* (in press) and Vacchi *et al.* (1999). Positive hauls of macrourids occurred in oceanic waters from the surface down to 700 m depth, between latitudes 68°34'90 S and 72°19'60 S and longitudes 173°36'18 E and 179°40'50 W (Fig. 1). Sampling data of each hauls are summarised in table II.

Most of the specimens were sampled in the period 1989-90 by means of the EZ NET BIONESS, a multiple opening-closing net sampler consisting of 10 nets, each with a mouth opening of $0.25\ m^2$ and a mesh size of 500 μm (Sameoto *et al.*, 1980). The hydrographic conditions, such as temperature, salinity, oxygen, etc., were measured for each tow by a multiparametric probe placed on the multiple-net sampler. Only three specimens were collected between November 1994 and January 1995, one of these by the EZ NET BIONESS and the other two by the Hamburg Plankton Net, a modification of the Isaacs-Kidd Midwater trawl with $5\ m^2$ mouth area and mesh size of 500 μm.

Each sample was sorted on board and the ichthyoplankton separated from the other zooplankton and stored in buffered 4% formaldehyde. Total length, i.e., the distance from the tip of the mandible to the tip of the tail, and other measurements reported below were made with an ocular micrometer to the nearest 0.1 mm. Following Taylor and van Dyke (1985), a few specimens were stained with the alizarin red S in order to enhance some osteological characters for taxonomic identification. As for the terminology used in this paper, the larval and postlarval stages are referred to the young after hatching with visible yolk-sac and to young without yolk-sac, respectively (Hureau, 1982).

For comparative purposes, specimens from stations V16 and 24A (see Table I) are deposited in the fish collection of the National Museum of Antarctica, Department of Genoa, with catalogue numbers 1473 and 1474, respectively.

Characters used for identification and description

From literature data (Fahay and Markle, 1984), the lack of a caudal fin, an elongate peduncular pectoral fin, and a long tail characterise the known macrourid larvae. During ontogenesis, the pelvic fin is the first fin to form rays, whereas the pectoral fin rays develop later. Additional characters most useful for species identification are the number of pelvic fin rays, the presence of retia mirabilia and their number (clearly visible from the postlarval stages onwards), and the pigmentation pattern. Conversely, some juvenile

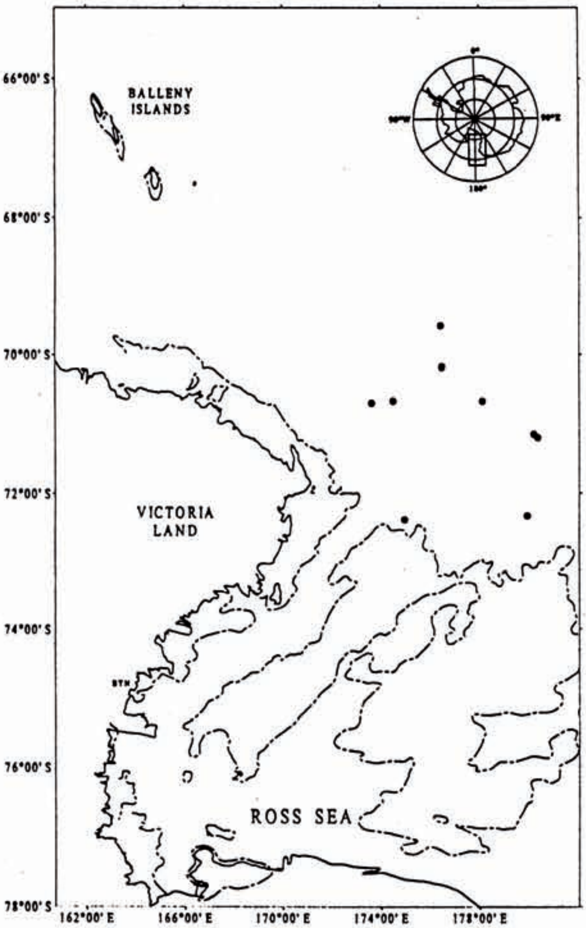

Fig. 1. - Spatial distribution of postlarval stages of *Macrourus whitsoni* sampled in the western Ross Sea during November 1989-January 1990 and November 1994-January 1995. Circles indicate only the positive sampling locations.

and adult diagnostic characters, such as mental barbel on lower jaw, smooth or serrate second spinous ray of the first dorsal fin, and luminescent organs, could not be used for the larvae as they develop later.

Following Efremenko (1985), body depth at anus level (H), head and snout (pre-orbital) length (HL and pO), eye diameter (O), and trunk or pre-anal length (pA) have been recorded and plotted against the total length, in order to follow their ontogenetic change. In the present paper, total length (TL), instead of head length (HL) which is customary in macrourid studies (Merrett, 1978), was used as reference size because all of our specimens had an undamaged tail. The description of pigmentation follows that of Russell (1976). The presence of distinct melanophores and/or a more diffuse pigment pattern will be outlined in the following discussion.

RESULTS AND DISCUSSION

Diagnosis and description

The taxonomic diagnosis was facilitated by the relatively low number of macrourid species reported from the Southern Ocean and by their distribution (Iwamoto, 1990). In agreement with Stein's (1980) assumption for the North Pacific, we also considered the larvae caught in the Ross Sea conspecific with adult macrourid fishes known to occur in the same area. In this way, only four out of ten macrourid species reported from the Southern Ocean were initially considered (Table I), namely *Coryphaenoides ferrieri*, *C. lecointei*, *Cynomacrurus piriei* and *Macrourus whitsoni* (Iwamoto, 1980).

The number of pelvic fin rays, which in macrourid ontogeny are formed first (Fahay and Markle, 1984), excludes the two species of *Coryphaenoides* (10-11 rays in both species). Finally, in contrast to *Cynomacrurus piriei*, the presence of a swimbladder with four retia mirabilia in the larger larvae allowed us to identify our specimens as *Macrourus whitsoni* (Regan, 1913).

Efremenko (1985) described larval and juvenile macrourids caught off South Georgia and identified them as *M. whitsoni*. Recently, Kellermann (1989) changed Efremenko's identification to *M. holotrachys*. Our data support this change, as the head morphology and pigment pattern of our specimens from the Ross Sea are very different from those of Efremenko's specimens. On the other hand, the 14.3 mm SL larva of *Cynomacrurus piriei* reported by Evseenko and Efremenko (1988) is very similar to our specimens of the same size and it may be provisionally redescribed as *M. whitsoni* (Evseenko, pers. comm.).

All the specimens caught in the Ross Sea showed the general distinct characters of larval macrourids, such as a very elongate tail, the lack of a caudal fin, and a well developed peduncular pectoral fin. The pelvic fin rays were fully formed in all individuals, whereas all other fin rays were undeveloped even in the larger specimens. The pigment pattern was rather similar in each specimen of the same size, showing a developmental trend to a more diffuse and extensive pigmentation with increasing size of the individual. Furthermore, it was remarkable that some larvae (4) were more or less unpigmented, but this could be an artefact of preservation.

11.2 mm TL (Fig. 2a). - At this developmental stage, the trunk is short and the body gradually tapers backwards to a long thin tail (pA: 35.7% TL; H: 7.1% TL). The head is massive and is characterised by a slightly concave upper profile and a short snout (HL: 17.8% TL; pO: 4.5% TL). The mouth is oblique and the lower jaw ends with a sharp corner. The eyes are round and large (O: 40% HL). The pelvic fins are well developed, with long rays not fully formed. The pectoral fin base has a characteristic peduncular shape, ending with a massive lobe surrounded by a fin fold not yet differentiated into rays. The dorsal and anal fins are not developed and appear as fin folds.

The body is scarcely pigmented, but diffuse pigmentation occurs on the peritoneal and dorsal (trunk) region. Scattered melanophores occur on the caudal tip (both epural and hypural), in the occipital region, and on the pectoral fin base.

13.0 mm TL (Fig. 2b). - The trunk is short and the body tapers posteriorly to a long thin tail (pA: 30% TL; H: 7.7% TL). The head is more tapered and characterised by a slightly concave dorsal profile and a short snout (HL: 16.1% TL; pO: 4.6% TL). The mouth is oblique and the lower jaw ends with a sharp corner. The eyes are round and large(O: 42.8% HL). The pelvic fins are developed, with eight long rays. The pectoral fin

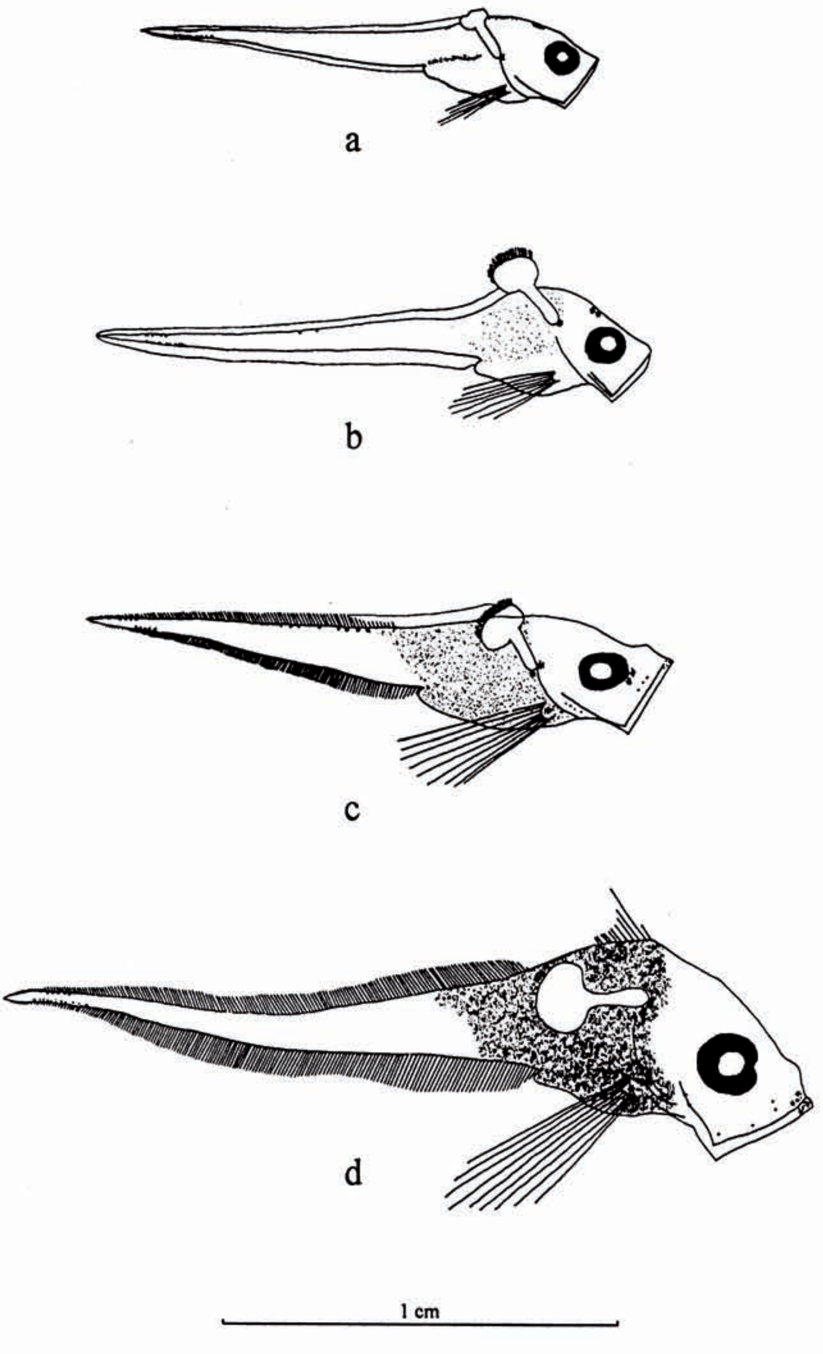

Fig. 2. - Postlarval stages of *Macrourus whitsoni*. **a**: 11.2 mm TL; **b**: 13 mm TL; **c**: 14.9 mm TL; **d**: 20.3 mm TL.

base is peduncular with a massive lobe surrounded by a fin fold not yet differentiated into rays. Both dorsal and anal fins are not developed and appear as fin folds.

The pigment pattern closely resembles that of the previous stage, but with the addition of diffuse pigmentation on the lateral abdominal region, on the trunk, and on the first caudal myomeres, as well as the presence of a few dorsolateral melanophores in the post-anal section.

14.9 mm TL (Fig. 2c). - The trunk is moderately short and the body is less slender (pA: 37.6% TL; H: 10.7% TL). The head is tapered and a prominence characterises the upper profile of the snout (HL: 20.8% TL; pO: 5.4% TL). The mouth is still oblique and the lower jaw ends with a sharp corner. The eyes are large (O: 38.7% HL). The pelvic fins are developed with nine very long rays. The pectoral fins base is still peduncular and undifferentiated. Both dorsal and anal fins are developing and some rays are formed.

The body is moderately pigmented, with a diffuse brownish pigmentation on the peritoneal, lateral and ventral abdominal and anal regions, on the trunk, and on the first caudal myomeres. Scattered melanophores occur on the caudal tip (both epural and hypural), in the occipital region, on the pectoral and pelvic fins base, in the opercular-preopercular region, on the lower jaw mid-membrane and on the snout. A single dorsolateral row of few melanophores is present on the post-anal section.

20.3 mm TL (Fig. 2d). - The trunk is short and the body is moderately stumpy (pA: 33.0% TL; H: 11.8% TL). The head is tapered and a prominence still occurs on the snout (HL: 19.7% TL; pO: 5.9% TL). The mouth becomes more horizontal; the lower jaw is still pointed. The eye becomes smaller than in earlier stages (O: 35% HL). The pelvic fins have nine long rays. The pectoral fin base is peduncular, undifferentiated, and is directed posteriorly. Both dorsal and anal fins are almost fully developed (D 11 + more than 100 rays).

The pigment pattern closely resembles that in previous stage, although the postlarva is generally more heavily pigmented. The post-anal section is unpigmented.

Abundance and distribution

On the whole, 23 postlarvae ranging from 10.6 to 20.3 mm were collected in oceanic waters of the Ross Sea from about 1300 to 3500 m bottom depth (except for station 24A). The horizontal distribution of *M. whitsoni* in the western Ross Sea showed a wide geographic range and were sampled at 10 different stations located between latitudes 69°S and 72°S and longitudes 173°E and 179°W. Our collection came from more than 80 midwater trawl hauls, most of which were made with multiple opening-closing nets. The mean relative abundance value, standardised to 100 m^3 of filtered sea water and referred to positive layers pooled, was 1.2 specimen.

Most catches occurred in the upper layer of the water column between the surface and 300 m depth, almost always below or close to the thermocline. As suggested by Marshall (1965), the settling of the macrourid larvae not far below the seasonal thermocline could be partially due to their feeding habit (see below).

Stomach content

One specimen, 18 mm TL, caught in December in the upper 100 m, had a fully filled stomach. Its diet was exclusively copepods, which have a peak density in the upper 100 m layer of the Ross Sea (Zunini Sertorio *et al.*, in press). Overall, 10 adult females of *Ctenocalanus citer*, ranging from 1.10 to 1.21 mm, and four copepodites (stages CIV and CV) of *Calanus propinquus*, ranging from 3.17 to 4.07 mm, were identified. The smaller species, *C. citer*, is one of the most abundant species of the zooplankton community of McMurdo Sound (Ross Sea), where it accounts for more than 20,000 specimens per 1,000 m^3 in the upper 100 m depth (Foster *et al.*, 1987). Late copepodite stages (CIV and CV) of *C. propinquus* migrate to the surface in spring, moult to adulthood and mate in the upper 200 m (Voronina, 1978: in Schnack-Schiel *et al.*, 1991). In agreement with our data, the stomachs of four macrourid larvae collected previously in McMurdo Sound contained zooplanktonic prey (Hopkins, 1987), indicating planktivory as the main feeding mode of the early life stages of these fishes.

Acknowledgements. - We are much indebted to Dr. Silvestro Greco for his useful co-operation in the field work, as well as to Prof. Tecla Sertorio who kindly identified copepods from the stomach content. The present study was financially supported by the Italian National Project of Antarctic Researches (PNRA).

REFERENCES

CIECHOMSKI J. de & C.I. BOOMAN, 1981. - Descripción de embriones y de áreas de reproducción de los granaderos *Macrourus whitsoni* y *Coelorhyncus fasciatus*, de la polaca *Micromesistius australis* y de balacao austral *Salilota australis* el la zona patagónica y fuegina del Atlántico Sudoccidental. *Physis*, 40(98): 5-14.

COHEN D.M., INADA T., IWAMOTO T. & N. SCIALABBA, 1990. - FAO species catalogue. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. FAO Fisheries Synopsis, 125(10), 442 p. Rome: FAO.

EFREMENKO V.N., 1985. - Illustrated guide to fish larvae of the Southern Ocean. BIOMASS Sci. Ser., 5: 74 p.

EVSEENKO S.A. & V.N. EFREMENKO, 1988. - Larvae of two species of Gadiformes and notes on the ichthyoplankton of the Australian-New Zealand Sector of the Antarctic. *J. Ichthyol.*, 28(5): 17-23.

FAHAY M.P. & D.F. MARKLE, 1984. - Gadiformes: Development and relationship. *In:* Ontogeny and Systematics of Fishes. (Moser *et al.*, eds.), pp. 265-283. Spec. Publ. n°1, American Society of Ichthyologists and Herpetologists. Lawrence (USA): Allen Press. Inc.

FOSTER B.A., CARGILL J.M. & J.C. MONTGOMERY, 1987. - Planktivory in *Pagothenia borchgrevinky* (Pisces: Nototheniidae) in McMurdo Sound, Antarctica. *Polar Biol.*, 8: 49-54.

GRANATA A., GUGLIELMO L., GRECO S., VACCHI M., SIDOTI O., ZAGAMI G. & M. LA MESA, in press. - Spatial distribution and feeding habits of larval and juvenile *Pleuragramma antarcticum* in the Western Ross Sea (Antarctica). *In:* Ross Sea Ecology (Faranda *et al.*, eds.), Springer Verlag.

GUGLIELMO L., COSTANZO G., ZAGAMI G., MANGANARO A. & A. ARENA, 1992. - Zooplankton ecology in the Southern Ocean. *Natl. Sci. Com. Antarct. Ocean. Camp. 1989-90, Data Rep. II*: 301-468.

HOPKINS T.L., 1987. - Midwater food web in McMurdo Sound, Ross Sea, Antarctica. *Mar. Biol.*, 96: 93-106.

HUREAU J.C., 1982. - Methods for studying early life history stages of Antarctic fishes. *Cybium*, 6(1): 3-11.

IWAMOTO T., 1990. - Macrouridae. *In:* Fishes of the Southern Ocean (Gon O. & P.C. Heemstra, eds), pp. 192-206. Grahamstown (South Africa): J.L.B. Smith Institute of Ichthyology; CTP Book Printers.

KELLERMAN A., 1989. - Identification key and catalogue of larval Antarctic fishes. BIOMASS Sci. Ser., 10: 136 p.

MARSHALL N.B., 1965. - Systematic and biological studies of the macrourid fishes, Anacanthini-Teleostei. *Deep-Sea Res.*, 12(3): 299-322.

MERRETT N.R., 1978. - On the identity and pelagic occurrence of larval and juvenile stages of rattail fishes (family Macrouridae) from 60°N, 20°W and 53°N, 20°W. *Deep-Sea Res.*, 25: 147-160.

RUSSELL F.S., 1976. - The Eggs and planktonic Stages of British marine Fishes. 524 p. London: Academic Press.

SAMEOTO D.D., JAROSZYNSKI L.O. & W.B. FRASER, 1980. - BIONESS, a new design in multiple net zooplankton sampler. *J. Fish Res. Board Can.*, 37: 722-724.

SCHNACK-SCHIEL S.B., HAGEN W. & E. MIZDALSKI, 1991. - Seasonal comparison of *Calanoides acutus* and *Calanus propinquus* (Copepoda: Calanoida) in the southeastern Weddell Sea, Antarctica. *Mar. Ecol. Prog. Ser.*, 70: 17-27.

STEIN D.L., 1980. - Description and occurrence of macrourid larvae and juveniles in the northeast Pacific Ocean off Oregon, U.S.A. *Deep-Sea Res.*, 27A: 889-900.

TAYLOR W.R. & G.C. VAN DYKE, 1985. - Revised procedure for staining and clearing small fishes and other vertebrates for bone and cartilage study. *Cybium*, 9(2): 107-119.

VACCHI M., LA MESA M. & S. GRECO, 1999. - Summer distribution and abundance of larval and juvenile fishes in the western Ross Sea. *Antarct. Sci.*, 11(1): 54-60.

ZUNINI SERTORIO T., LICANDRO P., OSSOLA C. & A. ARTEGIANI, in press. - Copepod communities in the Pacific sector of the Southern Ocean in early summer. *In:* Ross Sea Ecology (Faranda *et al.*, eds.), Springer Verlag.

Reçu le 12.05.1999.
Accepté pour publication le 15.10.1999.